



STEFFEN ROBERTSON AND KIRSTEN
Consulting Engineers

August 22, 1986
Project No. 05204

Hazen Research
4601 Indiana Street
Golden, Colorado 80401

Attention: Mr. Don Curtis

RE: KELMINE LISBON VALLEY COPPER PROJECT

Dear Don,

Please find attached a brief specification and a quality assurance plan for the clay liner placement at the Lisbon Valley Copper Project. We trust these are as you required and will expedite project permitting and construction.

The permeability testing currently underway on potential liner material still reflects permeabilities on the order of 10^{-7} cm/sec. We do not anticipate that any significant change in this value will occur. We indicated previously that the material had a swell potential upon saturation under low confining stress. It should be remembered that in the location planned for use of the clay, confining stresses will be adequate to prevent swell. The net effect of the physical change under a confining stress will be a tendency to reduce the void ratio and lower the permeability in comparison to the values equivalent to our laboratory test.

Should you have any question in regards to the documents, please contact us.

Yours truly,

STEFFEN ROBERTSON AND KIRSTEN
(COLORADO) INC.

Rob Dorey
Divisional Head
Mining Geotechnics

RD/dkh
Attachment

SITE PREPARATION
TECHNICAL SPECIFICATIONS FOR
KELMINE LISBON VALLEY COPPER PROJECT

Prepared for:
Hazen Research
4601 Indiana Street
Golden, Colorado 80401

Prepared by:
Steffen Robertson and Kirsten
3232 South Vance, Suite 210
Lakewood, Colorado 80227

August 1986

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The following specifications have been prepared by Steffen Robertson and Kirsten based on design information provided by Hazen Research, Inc.

1.0 INTRODUCTION

These specifications shall be used in conjunction with drawings prepared by Hazen Research, Inc. In these Specifications, the Engineer shall be the designated representative of the Owner and is professional engineer experienced in the construction of the type of work specified.

Should any contradictions, either implied or real, exist between the Specifications and the drawings, the Specifications shall take precedence. In all cases, the decision of the Engineer is final.

2.0 SITE PREPARATION

Site preparation will consist of stripping and grubbing, and preparing foundations of the various areas for their designated purpose. In general, these areas will include leach pads, solution trenches, process ponds, process areas, borrow areas, and access roads.

2.1 Stripping and Grubbing

The Contractor shall strip from foundation areas all vegetation, including roots in excess of 1 inch in diameter. Stripped and grubbed vegetation shall be disposed of by controlled burning in an area designated by the Engineer. The Contractor shall then strip topsoil to an average depth of 4 inches. All topsoil shall be stockpiled in the areas designated in the drawings or as instructed by the Engineer. Shaping of the stockpile shall be such as to minimize erosion and prevent ponding of precipitation in the stockpile area.

Other perishable and objectional materials that are unsuitable for use in permanent construction and which might interfere with proper bonding of fill materials with the foundations, or proper compaction of fill materials, or which are otherwise unsuitable as determined by the Engineer, shall be removed and wasted in an area designated by the Engineer.

2.2 Borrow Areas

To the extent practical, fine grained earth materials required for the work defined by these Specifications shall be obtained primarily from designated borrow areas. Material not available from said borrow areas shall be furnished by the Contractor from a source proposed by the Contractor and approved by the Engineer.

The Contractor may select and use any Engineer-approved borrow areas for construction materials, provided the materials meet the specification requirements for the intended use. The Contractor shall strip and grub the borrow areas of topsoil and other matter which is unsuited, as determined by the Engineer, for the purpose for which the borrow area is being developed. Said topsoil and other matter shall be disposed of in accordance with Section 2.1.

Compaction and grading tests on material excavated from borrow areas will be conducted by the Engineer to assess the adequacy of such material for use in the work. Said Engineer's tests shall not relieve the Contractor from the responsibility to furnish materials which conform to the Specifications for the material being furnished. Selective borrowing may be necessary in the borrow areas to obtain materials of proper soundness and gradation.

The borrow shall be operated so as not to impair the usefulness or unnecessarily mar the appearance of any part of the work or any property of the Owner. The surfaces of all borrow areas and wasted materials shall be left in reasonably smooth, even conditions, sloped for proper drainage and long-term slope stability, and left in a condition satisfactory to the Engineer.

2.3 Foundation Preparation

2.3.1 General

All foundations of earthworks shall be prepared in accordance with Section 2.1 of these Specifications. In addition, at the completion of the required foundation stripping operations and removal of unsuitable foundation material, the entire surface shall be fine-graded, as approved by the Engineer, such that no pockets or streaks of loose or disturbed material exist on the surface of the foundation. No fill shall be placed until the foundation has been inspected by the Engineer. An initial survey will be required to verify the required slope, and to establish elevations to determine the final liner thickness.

2.3.2 Soil Foundation Surfaces

Where soil foundation surfaces exist where compacted fill is to be placed, the foundation surface shall be prepared by compaction by vibratory or pneumatic-tired rollers, whichever best suits the foundation material. Compaction effort shall be equivalent to twice that required to obtain the density specified for the particular fill material to be placed upon the foundation.

3.0 FILL PLACEMENT

3.1 Placement

The procedures for the placement of fills shall be discussed with and approved by the Engineer prior to fill placement.

No brush, roots, sod, or other deleterious or unsuitable materials shall be placed in the fills. Fill shall not be placed upon a frozen surface, nor shall snow, ice, or frozen material be incorporated into the fill. Fill placement shall be temporarily stopped due to unsuitable weather conditions, upon the direction of the Engineer.

Except as otherwise specified, compacted fill materials shall be placed on surfaces at a moisture content equivalent to that of the fill to be placed.

The distribution of materials within any given fill shall be such that the fill is free from lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. The combined borrow excavation and fill placement operation shall be such that the materials, when compacted in the fill, will be blended sufficiently to secure the best practicable distribution of the material.

If, in the opinion of the Engineer, the surface of the prepared foundation or the surface of any layer of the fill is too dry or too smooth to bond properly with the layer of material to be placed thereon, it shall be moistened and/or worked with harrow, scarifier, or other equipment to provide a satisfactory bonding surface before the next layer of fill material is placed. If, in the opinion of the Engineer, the surface of the prepared foundation or the rolled surface of any layer of the fill in place is too wet for proper compaction of the layer of fill material to be placed

thereon, it shall be removed and allowed to dry or shall be worked with harrow, scarifier, or other equipment to reduce the moisture content to the required amount, and then compacted before the next layer of fill material is placed.

3.2 Moisture Control

During compaction operations, the materials being placed and the surface of the fill shall be maintained within the moisture content range required to permit proper compaction to the specified density with the equipment being used. The moisture content of the earthfill material during compaction shall be uniform throughout each layer of the material. The required degree of compaction can be obtained with a reasonable effort within the moisture range defined by the Engineer, which, in general, will be within plus or minus 2 percent of the optimum moisture content, as defined by ASTM D-698.

When material spread on the fill is too dry for proper compaction, the Contractor shall spray water on each layer of the fill and work the moisture into the fill by harrowing or other approved means until a uniform distribution of moisture is obtained. Material that is too wet for proper compaction shall be removed from the fill or the material may be spread out and permitted to dry, assisted by disking and harrowing, if necessary, until the moisture content is reduced to an amount suitable for obtaining the specified degree of compaction.

3.3 Compaction

Wherever necessary after each layer of fill material has been placed, spread, and moisture conditioned as specified above, the layer shall be compacted by passing compaction equipment over the entire surface of the layer a sufficient number of times to obtain the required density, as determined on the basis of field density tests.

The Engineer will continuously evaluate the Contractor's equipment and methods. If such equipment or methods are found unsatisfactory for the intended use, the Engineer will require the Contractor to replace the unsatisfactory equipment with other types or adjust methods until proper compaction is achieved. Density shall be based on ASTM D-698 for cohesive soils and a minimum compaction of 95 percent of the laboratory Standard Proctor dry density shall be achieved for fine grained materials, Section 3.8.

3.4 Proof Rolling

The Contractor shall proof-roll areas receiving a synthetic liner no sooner than 24 hours before installation of the liner. Proof rolling shall leave a uniformly smooth surface with no protuberances or depressions. The final surface shall be to the standards recommended by the liner manufacture and shall be approved by the Engineer before synthetic liner installation. A survey of the surface will be required to verify the thickness of clay liner.

3.5 Sequence of Operations

The Contractor shall construct the fills such that the fill is approximately level at all times during construction. The surface of the fill shall be graded to prevent ponding of rainwater or snowmelt.

At the end of each shift or day, the Contractor shall leave the surface of compacted fill in such a manner as to prevent an excessive increase in moisture content arising from precipitation. The Engineer will require that the top layer be removed at the recommencement of fill placement if it has become too wet or is softened as a result of precipitation.

3.6 Contamination

The Contractor shall route equipment and take all actions necessary to prevent material of one type from being deposited inadvertently, either by dumping or through travel of equipment, in or on material of another type. Such improperly deposited material shall be removed from the fill. Said removed material shall be wasted in locations designated by the Engineer.

All stones of such dimensions that interfere with compaction in the layer thicknesses specified shall be removed from the zone in which they are placed prior to compaction as specified.

3.7 Conduct of Work

The Contractor shall maintain and protect fills in a condition satisfactory to the Engineer at all times until the final completion and acceptance of the work. Any approved fill material which becomes unsuitable for any reason whatsoever, after being placed in the fill and before final acceptance of the work, shall be removed and replaced by the Contractor in a manner satisfactory to the Engineer.

3.8 Type 1- Fine Grained Material

3.8.1 Scope of Work

The Contractor shall borrow, transport, place, and compact Type 1 material in the impervious earth liners and around drainage pipes as shown on the drawings, and as set forth in these Specifications, or as specified by the Engineer.

3.8.2 Material - Type 1

Type 1 material shall consist of "Fine Grained" material from approved borrow areas. The material shall contain a minimum of 30 percent of minus No. 200 U.S. sieve size and be capable of following compaction to obtain a hydraulic conductivity of a maximum of 10^{-7} cm/sec as determined by the Engineer.

3.8.3 Source

A potential borrow area for Type 1 material is located on site. Areas other than this may be proposed by the Contractor, but such other areas shall be subject to investigation and approval in accordance with Section 2.2. of these Specifications. Samples of Type 1 material shall be submitted to and tested by the Engineer prior to development of the borrow area.

3.8.4 Placement and Compaction - Type 1 Material

Type 1 material shall be compacted in a loose layer not exceeding six inches thickness, to a dry density of not less than 95 percent of the maximum dry density as determined in accordance with ASTM D-698. The compacted thickness for lifts on all areas where clay liners are specified shall be six inches. A final survey will be made to verify the liners thickness.

3.9 Type 2 - Random Fill

3.9.1 Scope of Work

The Contractor shall furnish, transport, place, and compact Type 2 material as shown on the drawings and as

set forth in these Specifications, or as specified by the Engineer. Type 2 material shall be principally used in the construction of the retention berms and for general fill requirements..

3.9.2 Material - Type 2

Type 2 material shall consist of random fill from approved borrow areas or required excavation. The material shall be a well-graded mixture of various materials with a maximum partical size of 6 inches.

3.9.3 Source

From required excavation if such excavated material complies with this Specification. Areas other than this may be proposed by the Contractor, but such other areas shall be subject to investigation and approval in accordance with Section 2.2 of these Specifications.

3.9.4 Placement and Compaction - Type 2 Material

Type 2 material shall be placed in loose lifts not exceeding 8 inches and compacted by controlled movement of haulage and placement equipment. A minimum density of 95 percent of the standard Proctor shall be achieved. Maximum partical size shall be 6 inches.

3.10 Type 3 - Sand and Gravel

3.10.1 Scope of Work

The Contractor shall furnish, transport, and place Type 3 material as shown on the drawings and set forth in the Specifications, or as specified by the Engineer.

3.10.2 Material

Type 3 gravel shall be clean, round, processed, non-calcareous, sound and durable sand-gravel mixtures. The material shall be well-graded with $\frac{1}{2}$ " maximum size gradation.

The actual gradation for Type 3 material shall be submitted by the supplier to the Engineer for approval prior to use.

3.10.3 Source

The source of Type 3 material shall be approved by the Engineer prior to development.

3.10.4 Placement

Type 3 material shall be placed to the lines and grades, and in the locations shown on the drawings, or specified by the Engineer. Hand raking and placement of the material shall be performed if required to produce the required thickness of material on inclined surfaces.

4.0 SYNTHETIC LINER

4.1 General

Synthetic liners will be installed on the leach pad and solution ponds.

Prior to placement of liner materials on the leach pad area, the clay liner shall be prepared in accordance with Section 3.0. The prepared surface shall be in a condition which will be approved by the liner installer prior to synthetic liner placement.

As specified on the Drawings, approximately six inches of Type 3 material, sand and gravel will be placed over the clay liner. This material will be placed and prepared in such a manner as approved by the synthetic liner installers recommendations. This surface will be approved by the synthetic liner installer prior to placement of synthetic liner materials.

CLAY LINER QUALITY ASSURANCE
PROGRAM FOR KELMINE LISBON
VALLEY COPPER PROJECT

Prepared for:
Hazen Research, Inc.
4601 Indiana Street
Golden, Colorado 80401

Prepared by:
Steffen Robertson and Kirsten (Colorado) Inc..
3232 South Vance Street, Suite 210
Lakewood, Colorado 80227

August 1986

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1.0 INTRODUCTION

This Quality Assurance program shall be used in conjunction with the Drawings prepared by Hazen Research, Inc. Should any contradictions, either implied or real, exist between the Drawings and this Quality Assurance program, the decision of the Owner's designated Engineer shall prevail. In all cases, the decision of the Engineer shall be final.

Clay liners will be used in the contraction of various containment and processing areas as specified on the Drawings.

To ensure that the quality of the clay liner conforms to the minimum specified requirements, the following construction procedures, observation, and testing program will be used.

2.0 CONSTRUCTION PROCEDURE

2.1 Foundation Material

Underlying the proposed clay liner material, as shown in Figure 1, shall be a well compacted nonyielding material. Density tests will not be required on this material unless the Engineer feels it necessary. The method of testing will be tailored to the conditions encountered at that time.

The prepared foundation will be proof rolled prior to placement of any clay liner materials. The entire surface will be visually inspected during the proof rolling procedure. Equipment to be used will be heavy rubber tired, loaders or fully loaded haul trucks.

Any area which yields under the weight of the equipment will be marked, reworked or replaced with a suitable material. The reworked or replaced material will be proof rolled prior to acceptance.

Prior to the placement of any clay liner materials, the foundation surface must be surveyed to verify the required slope, and also will serve as a base line elevation to verify the thickness of clay liner placed. The minimum thickness of clay liner is shown on Figure 1.

2.2 Clay Liner Placement

Clay liner materials to be placed will be visually inspected and tested for the proper moisture content and plasticity index prior to use. Gradations will be run to verify the maximum particle size and the minimum amount of -200 materials required. Refer to Table 1 for the number and frequency of tests.

Natural moisture contents are well below the optimum range for workability in accordance with ASTM D-698 test methods. Moisture can be added at the borrow site as well as on the grade. The materials will be mixed thoroughly. No dry streaks or unmixed material will be compacted. A homogeneous material will be required prior to any compactive effort.

2.2.1 Lift Thickness

All clay liner placement will consist of two, six-inch compacted lifts, for a total of 12-inch compacted liner material. After testing the first lift has been completed and densities verified, the lift shall be lightly scarified to establish a bond between the first and second lift. One-inch scarification will be adequate.

The emergency pond shall be constructed in four (4) six-inch compacted lifts. The scarification procedure shall be the same.

3.0 ON-SITE VERIFICATION TESTING PROGRAM

3.1 Foundation Materials

As discussed in Section 2.1.

3.2 Borrow Materials

The borrow area to be used, or any source of imported material will be tested, prior to any materials being placed. The minimum number of tests will be one per each type of material encountered. The material will be tested for moisture content, grain-size analysis, and plasticity index. Compaction curves (Proctors) may be run, but in most cases will not be run until the material has been placed on the grade and compacted. For further discussion on compaction curves, see Section 3.3

3.3 Testing of Inplace Material

Two types of compaction control will be used to determine the inplace density. Refer to Figure 2 for the test procedures.

Figure 2 does not address general process areas where clay liners are specified such as ore-pretreatment and main process areas. Similar quality assurance guidelines will be employed in the areas as required by the Engineer.

3.4 Frequency of Testing

The frequency of tests performed during the construction of clay liners will be determined by the Engineer, but in no case shall the minimum number of tests be less than those indicated on Table 1.

3.5 Density Test Series Locations

Nonbiased plans will be used for locating test sites and samples. Figure 3 outlines this procedure and shows the plans to be used.

3.6 Liners and Grades

As part of the construction procedure, a survey of grade and elevations will be required. The foundation materials shall be placed to the slope and elevations as specified. Grade stakes shall be maintained throughout construction. A final survey will be required to verify that the minimum sections of liner materials has been achieved as specified on the Drawings.

3.7 Permeability

A minimum of three samples will be obtained from clay materials within the leach pad area. A minimum of one sample will be obtained for each pond and other areas where clay liners are specified. In addition to these minimum samples, any material encountered which differs from materials tested and is used in the construction of the clay liners will be sampled for testing.

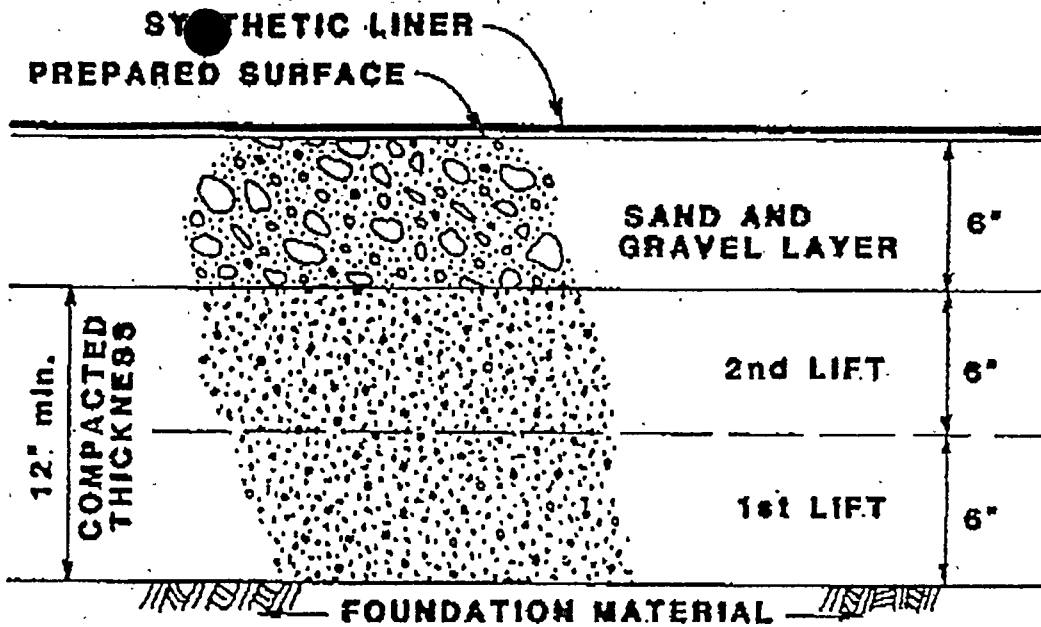
TABLE 1
FREQUENCY OF TESTS

AREA OR LOCATION	TYPE OF TEST	DESIGNATION	MINIMUM NUMBER OF TESTS OR SAMPLES
Borrow Material or Imported Material	Moisture Content Partical Size Atterbergs Proctor	ASTM D-2216 ASTM D-421/422 ASTM D-4318 ASTM D-698	One test per soil type One test per soil type One test per soil type One test per soil type
CLAY LINERS			
Leach Pad 2-6" Lifts	Density Series*	CAL-231 E-25 or ASTM D-698	Three series on 1st 6" lift Four series on 2nd 6" lift
Total Area 22,670 yd ²	Partical Size Atterbergs Permeability	ASTM D-421/422 ASTM D-4318 **	One per each density series One per each density series Three samples obtained for lab testing
Solution Ponds 2-6" Lifts	Density Series	CAL-231 E-25 or ASTM D-698	One series on 1st 6" lift One series on 2nd 6" lift
Total Area/Pond 3,330 yd ² (1,000 yd ² /Fe-A1 Settling Pond)	Partical Size Atterbergs Permeability	ASTM D-421/422 ASTM D-4318 **	One per each density series One per each density series One sample obtained for lab testing
Emergency Pond 4-6" Lifts	Density Series	CAL-231 E-25 ASTM D-698	One series on 1st 6" lift One series on 2nd 6" lift One series on 3rd 6" lift One series on 4th 6" lift
Total Area 1,640 yd ²	Partical Size Atterbergs Permeability	ASTM D-421/422 ASTM D-4318 **	One per each density series One per each density series One sample obtained for lab testing

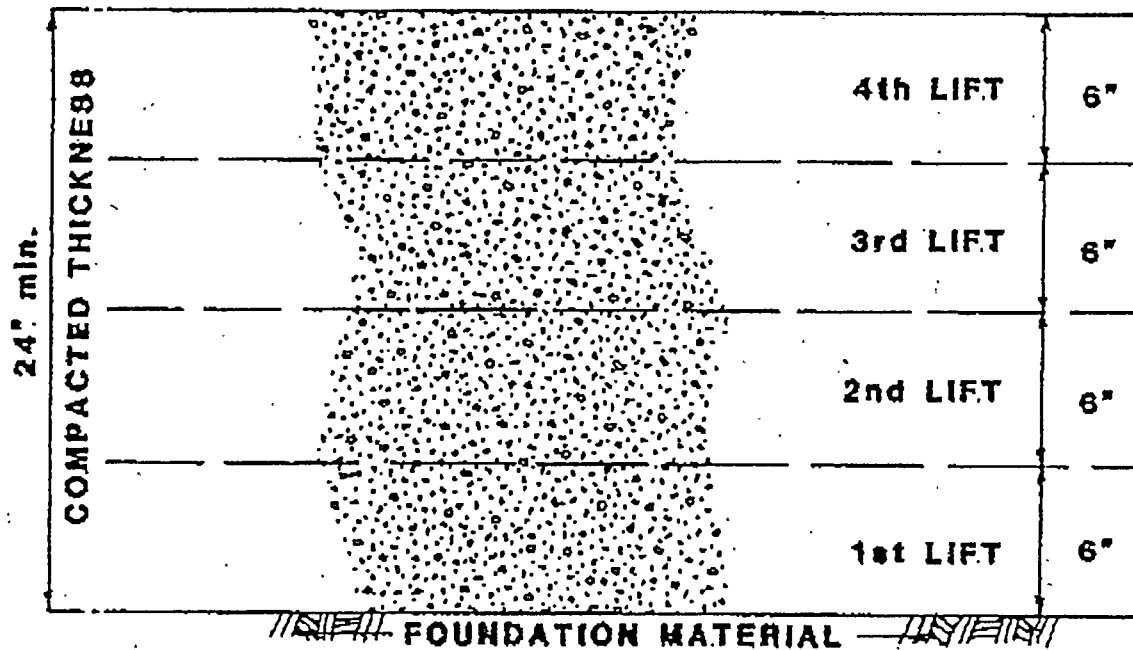
*A density series consists of a minimum of three tests, up to 10 per area tested.

Additional tests or samples may be requested by the Engineer.

**Permeability test designation - EM 1110-2-1906 Appendix 7.



SOLUTION PONDS AND LEACH PADS



EMERGENCY POND

PROJECT No.
05204

DATE
8/86

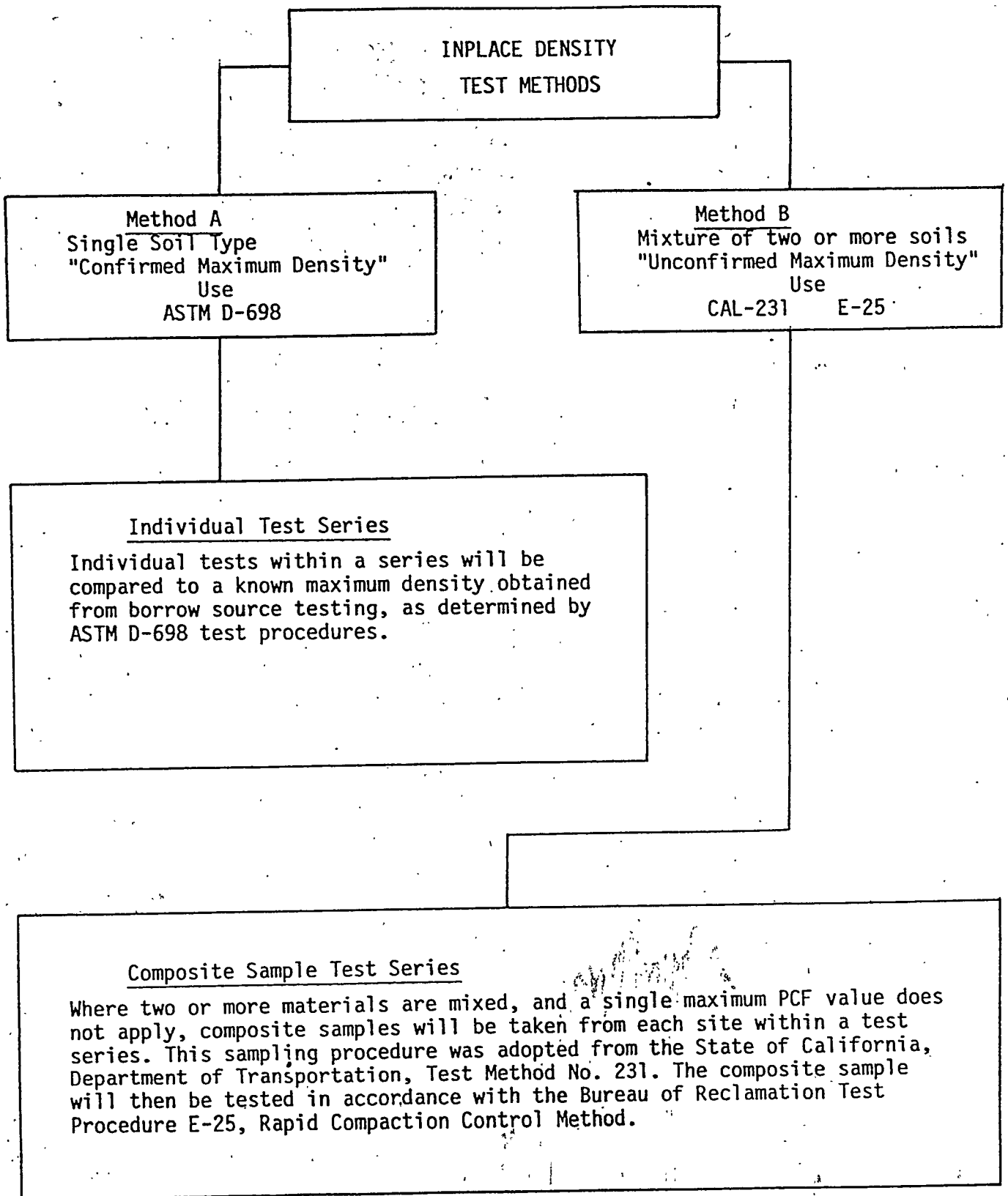
REVISION
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STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers

FIGURE 1

TYPICAL LINER DETAILS



Test Series: Depending upon total area to be tested, from three to 10, individual density tests will be made within the series.

Figure 2

FIGURE 3

NONBIASED SAMPLE PLANS

Once an area is selected on the basis of uniformity of factors, nonbiased location of measurement sites is required for applying statistical control procedures. The nonbiased sample location plans will randomly locate the approximate measurement sites.

Note: The number of measurement sites must be determined after the area has been determined and *before* any tests performed.

PROCEDURE FOR USE OF NONBIASED SAMPLE PLANS

1. a. Use the last digit from the first reading taken for the daily standard count to select the plan for the first area. For subsequent areas use the last digit from the second, third, and fourth readings. If five through nine areas are tested, use the second to the last digit from the first through the fourth readings

taken for the daily standard count.

- b. Nuclear gages that electronically average the standard counts—Take a $\frac{1}{4}$ minute count in the safe position at any convenient location, i.e., ground, truck bed, carry case, etc., prior to selecting the plan for an area. Use the last digit of the density reading for selecting the plan. A new count should be taken for each area.

2. Visualize the plan as a map of the area to be sampled.
3. Each dot represents a measurement site. There are 10 dots numbered from one (1) through ten (10). If you are to take a five (5) site test, then use the dots numbered from one (1) through five (5). If a three site test is going to be used, then use the locations of the first three dots. This procedure will be used for all tests, with Number 1 dot the first site, Number 2 dot the second site and so on until the desired number of sites have been used.
4. Test at the approximate locations on the grade represented by the dots on the plan. Some adjustments are necessary for irregular areas:

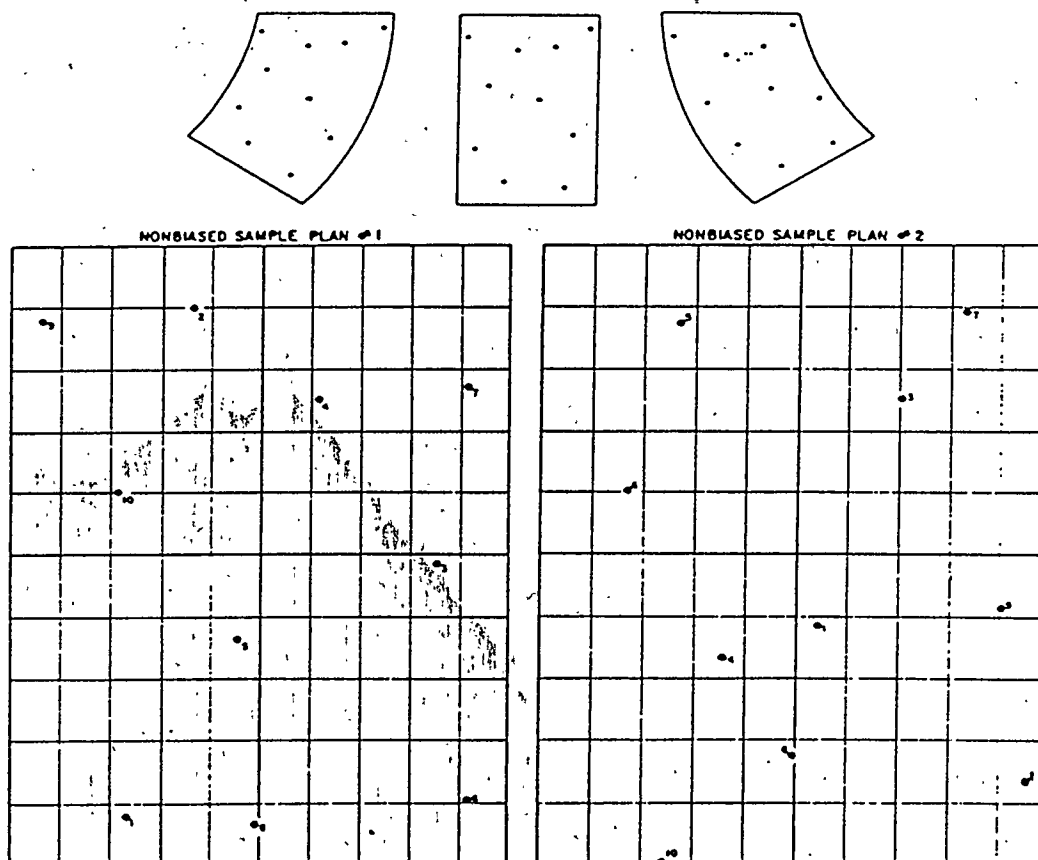


FIGURE 3

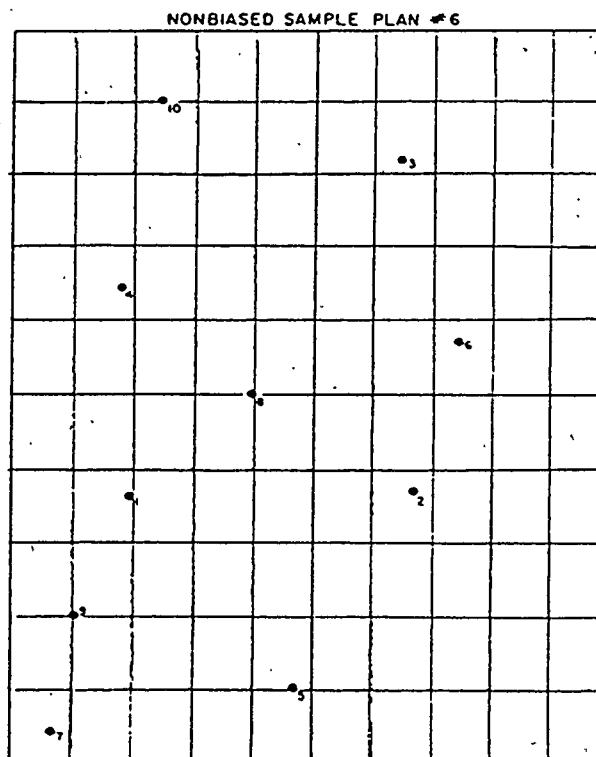
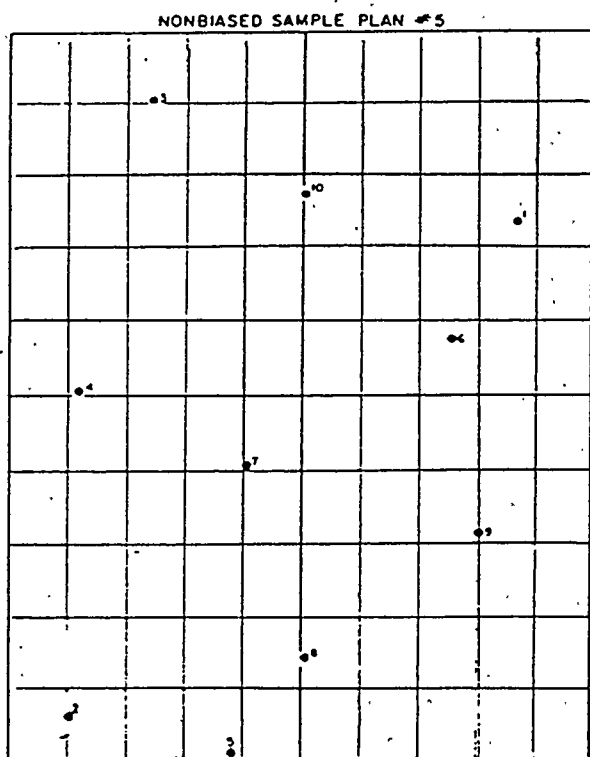
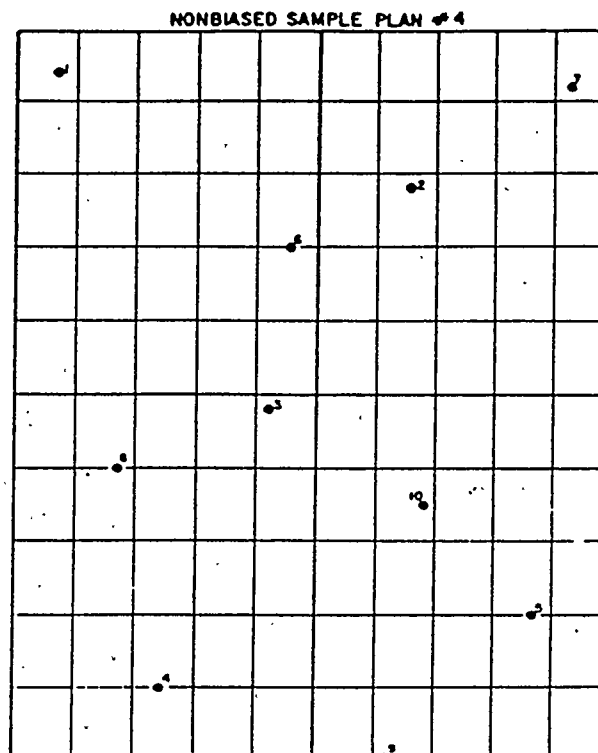
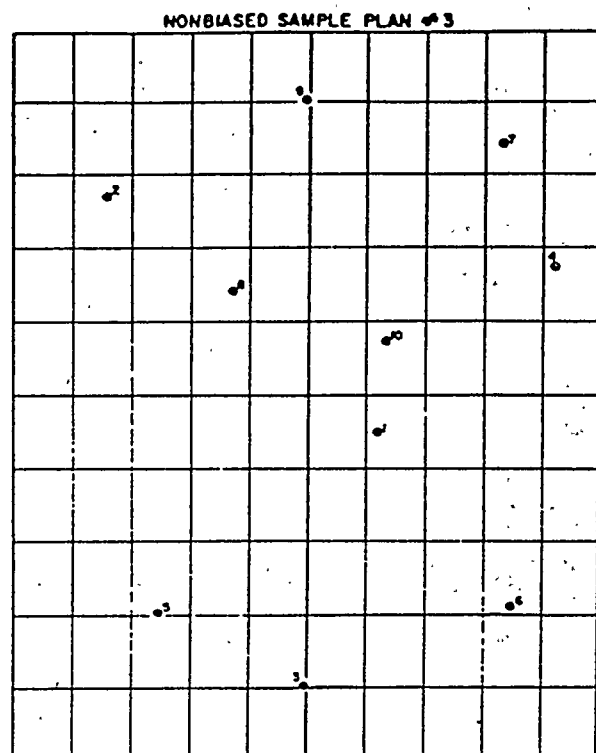


FIGURE 3 (Continued)

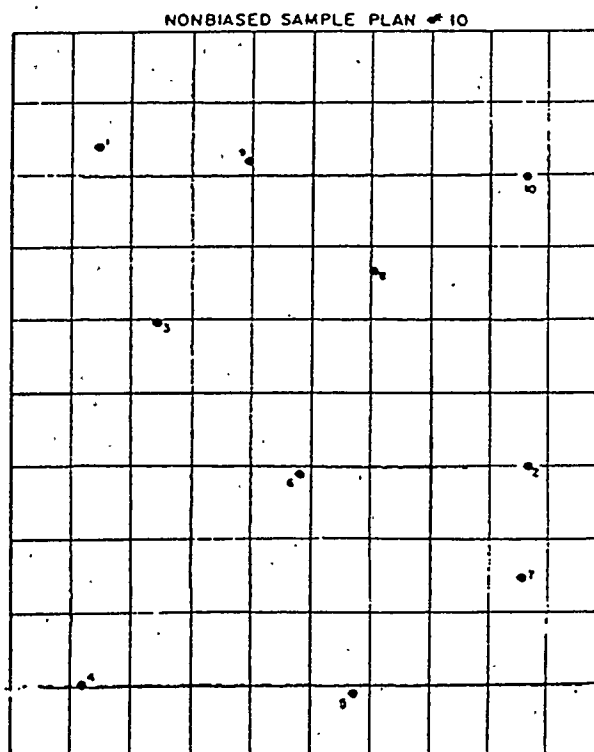
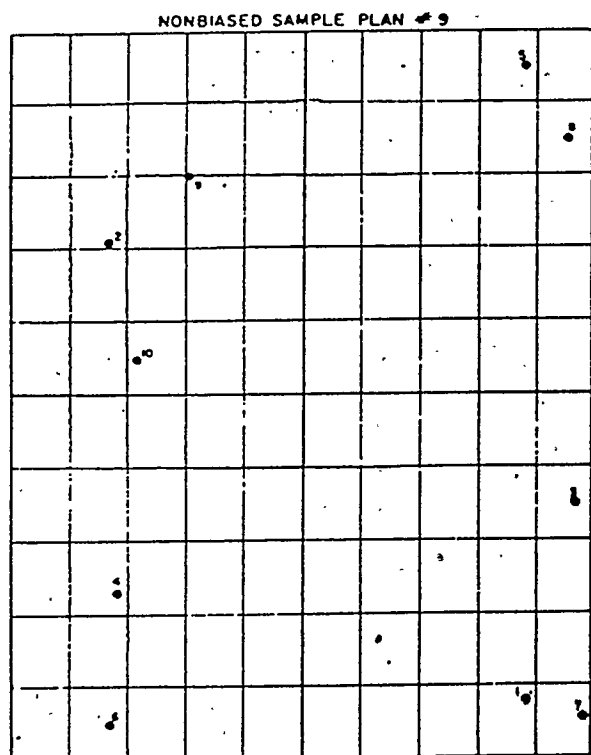
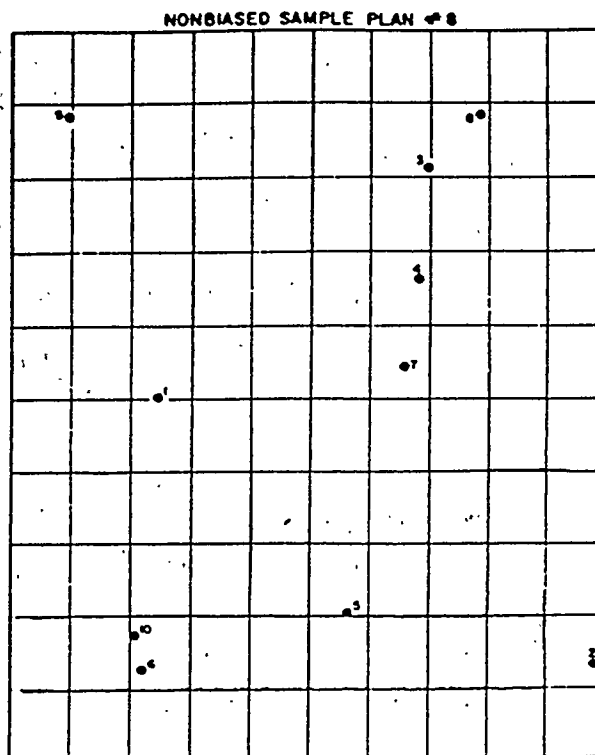
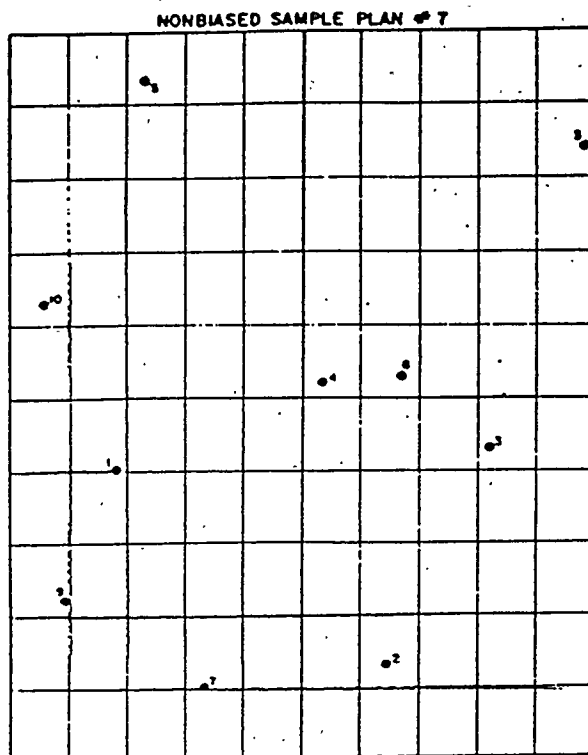


FIGURE 3 (Continued)